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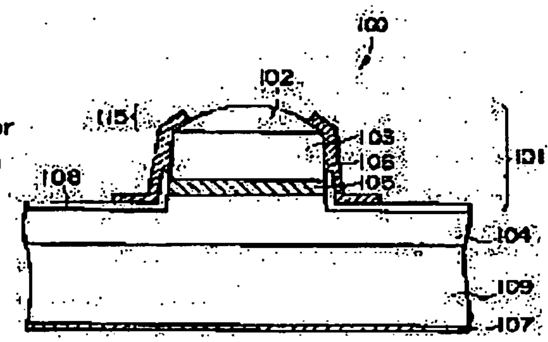
(54) SURFACE EMITTING SEMICONDUCTOR LASER AND MANUFACTURE THEREOF

(57)Abstract:

PROBLEM TO BE SOLVED: To provide surface emitting semiconductor laser permitting to set a radiation angle of the laser small even if the laser is increased in power.

SOLUTION: This surface emitting semiconductor laser has a resonator vertical to a semiconductor substrate, and emits laser light from the resonator in the direction vertical to the semiconductor substrate. At least cylindrical semiconductor accumulation (cylindrical part) 101 containing a part of the resonator is contained. A contact layer 102 of the cylindrical part 101 forms a lens shape part 115 having a convex lens surface.



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CLAIMS

[Claim(s)]
[Claim 1] Field luminescence mold semiconductor laser from which it has a vertical resonator on a semi-conductor substrate, the semi-conductor deposition object of the shape of a column which is the field luminescence mold semiconductor laser which carries out outgoing radiation of the laser beam in the direction perpendicular to said semi-conductor substrate from said resonator, and contains said some of resonators at least is included, and the laser outgoing radiation side of the top face of said semi-conductor deposition object constitutes a convex lens side.
[Claim 2] The lens configuration section which has said convex lens side in claim 1 is the field luminescence mold semiconductor laser containing the contact layer which constitutes said semi-conductor deposition object.
[Claim 3] It is the field luminescence mold semiconductor laser which consists of a simple substance of a contact layer with which said lens configuration section constitutes said semi-conductor deposition object in claim 2.
[Claim 4] It is the field luminescence mold semiconductor laser which consists of a lens layer by which said lens configuration section was formed on said contact layer and this contact layer in claim 2.
[Claim 5] It is the field luminescence mold semiconductor laser by which said lens layer is constituted from a semi-conductor layer which has a bigger band gap than the band gap equivalent to the energy of a laser beam in claim 4, and said contact layer is constituted from a semi-conductor layer with a band gap smaller than said lens layer.
[Claim 6] Said lens layer is field luminescence mold semiconductor laser from which it consists of two or more layers from which a refractive index differs in claim 4, and the refractive index of this lens layer changes in multistage.
[Claim 7] claim 6 — setting — said lens layer — the 1st lens layer — this — the field luminescence mold semiconductor laser to which said 2nd lens layer is located in a high order from said 1st lens layer including the 2nd lens layer with a larger refractive index than the 1st lens layer.
[Claim 8] It is the field luminescence mold semiconductor laser whose refractive index is the layer from which said lens layer is changing continuously in claim 4.
[Claim 9] It is the field luminescence mold semiconductor laser whose semi-conductor deposition object of the shape of said column is a mesa-like in either claim 1 - claim 8.
[Claim 10] It is the field luminescence mold semiconductor laser to which the shape of a curved surface ******** [object / of the shape of said column / semi-conductor deposition] in the side face in either claim 1 - claim 8 is made.
[Claim 11] The manufacture approach of the field luminescence mold semiconductor laser containing following process (a) - (d).
(a) The process which deposits two or more semi-conductor layers, and forms a semi-conductor deposition object on a semi-conductor substrate, (b) The process which forms the 1st resist layer of a predetermined pattern on said semi-conductor deposition object, (c) The process which is made to heat and carry out a reflow of said 1st resist layer, fabricates this resist layer in a convex lens-like configuration, and forms the 2nd resist layer, and (d) etching remove said 2nd resist layer at least. The process which forms the lens configuration section by which the configuration of said 2nd resist layer was reflected in the upper part of said semi-conductor deposition object.
[Claim 12] It is the manufacture approach of the field luminescence mold semiconductor laser containing the contact layer from which the lens configuration section constitutes said semi-conductor deposition object in claim 11.
[Claim 13] It is the manufacture approach of field luminescence mold semiconductor laser which consists of a simple substance of a contact layer with which said lens configuration section constitutes said semi-conductor deposition object in claim 11.

[Claim 14] It is the manufacture approach of field luminescence mold semiconductor laser which consists of a lens layer by which said lens configuration section was formed on said contact layer and this contact layer in claim 11.
[Claim 15] It is the manufacture approach of field luminescence mold semiconductor laser that said lens layer consists of semi-conductor layers which have a bigger band gap than the band gap equivalent to the energy of a laser beam in claim 14, and said contact layer consists of semi-conductor layers with a band gap smaller than said lens layer.
[Claim 16] Said lens layer is the manufacture approach of field luminescence mold semiconductor laser that consist of two or more layers from which a refractive index differs in claim 14, and the refractive index of this lens layer changes in multistage.
[Claim 17] claim 16 — setting — said lens layer — the 1st lens layer — this — the manufacture approach of field luminescence mold semiconductor laser that said 2nd lens layer is located in a high order from said 1st lens layer including the 2nd lens layer with a larger refractive index than the 1st lens layer.
[Claim 18] It is the manufacture approach of field luminescence mold semiconductor laser that a refractive index is the layer from which said lens layer is changing continuously in claim 14.
[Claim 19] The etch selectivity of said semi-conductor deposition object to the resist layer in [in / on claim 11 and / said process (d)] said etching is the manufacture approach of the field luminescence mold semiconductor laser which is 0.5-1.0.
[Claim 20] It is the manufacture approach of the field luminescence mold semiconductor laser made by the reactant ion-beam-etching approach that said etching added [in / on claim 11 and / said process (d)] oxygen to chlorine-based gas.
[Claim 21] The manufacture approach of the field luminescence mold semiconductor laser which etches said some of semi-conductor deposition objects by using said 2nd resist layer as a mask, and forms the semi-conductor deposition object of the shape of a mesa-like column after said process (c) in claim 11.
[Claim 22] The manufacture approach of the field luminescence mold semiconductor laser which forms the semi-conductor deposition object and said lens configuration section of the shape of said column by using said 2nd resist layer as a mask in said process (d) in claim 11.

[Translation done.]

DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Field of the Invention] This invention relates to the field luminescence mold semiconductor laser which carries out outgoing radiation of the laser beam perpendicularly to a semi-conductor substrate, and its manufacture approach.
[0002]
[Background of the Invention] In recent years, the plastic optical fiber attracts attention as a fiber for optical communication of an end system. Since a plastic optical fiber is rich in flexibility, being able to install by low cost and excelling in reinforcement moreover, since [that a core diameter is very large] connection is easy compared with the conventional quartz fiber, handling is equipped with the description of being easy.
[0003] A surface emission-type laser is mentioned as the light source applied to a plastic optical fiber. The

surface emission-type laser has the outstanding description [angle / laser outgoing radiation] compared with end-face laser that it is small isotropic. Thus, incidence of the laser beam can be directly carried out to an optical fiber exactly and efficiently by applying a surface emission-type laser with a small laser radiation angle to a plastic optical fiber with a large core diameter, without minding a lens between an optical fiber and the light source. The optical-communication module which consists of a thereby very easy configuration is realizable.
[0004]
[Problem(s) to be Solved by the Invention] However, since there is a fault that transfer loss is large, in order to lengthen a transmission distance, the light source of a big optical output is needed for a plastic optical fiber. In order to increase the laser output of a surface emission-type laser, it is effective to enlarge laser outgoing radiation aperture. However, if laser outgoing radiation aperture is enlarged, the problem that a radiation angle becomes large will arise. It results in causing directly, the fall of the quantity of light of the laser beam in which increase of a radiation angle carries out incidence to joint effectiveness, i.e., fiber incore, reduction of an installation margin, etc., when incidence is performed for a laser beam to an optical fiber for simplification of the configuration of an optical transmitting module, without minding a lens between direct coupling, i.e., an optical fiber, and the light source. Therefore, there was a problem that coexistence of simplification of securing the die length of a transmission distance and the configuration of the optical transmitting module by direct coupling was difficult.
[0005] Even if the above-mentioned coexistence is achieved and the purpose of this invention specifically increases a laser output, it is to offer the field luminescence mold semiconductor laser which makes it possible to set up the radiation angle of a laser beam small, and its manufacture approach.
[0006]
[Means for Solving the Problem] The field luminescence mold semiconductor laser of this invention has a vertical resonator on a semi-conductor substrate, it is the field luminescence mold semiconductor laser which carries out outgoing radiation of the laser beam in the direction perpendicular to said semi-conductor substrate, and the semi-conductor deposition object of the shape of a column which contains said some of resonators at least is included, and the laser outgoing radiation side of the top face of said semi-conductor deposition object constitutes a convex lens side from said resonator.
[0007] Thus, since the laser outgoing radiation side of the top face of a column-like semi-conductor deposition object (henceforth the "pillar-shaped section") constitutes the convex lens side, in a laser outgoing radiation side, a laser beam can be made refracted and the radiation angle can be narrowed. Moreover, according to this, since a radiation angle is controllable in a laser outgoing radiation side, since a laser output is increased, even if it enlarges laser outgoing radiation aperture, it also becomes possible to set up a radiation angle small.
[0008] As for the lens configuration section which has said convex lens side, it is desirable to include the contact layer which constitutes said semi-conductor deposition object.
[0009] The lens configuration section containing a contact layer can take the configuration of a publication below.
[0010] (1) Said lens configuration section is set to the 1st from the simple substance of the contact layer which constitutes said semi-conductor deposition object.
[0011] Thus, when the lens configuration section consists of a simple substance of a contact layer, the laminating of another semi-conductor for the lens configuration section cannot be carried out, and a routing counter can be stopped to the minimum.
[0012] (2) Said lens configuration section is set to the 2nd from said contact layer and the lens layer formed on this contact layer.
[0013] Thus, thin film-ization of a contact layer can be attained by having prepared the lens layer on the contact layer.
[0014] Moreover, said lens layer consists of semi-conductor layers which have a bigger band gap than the band gap equivalent to the energy of a laser beam in this case, and, as for said contact layer, it is more desirable than said lens layer for a band gap to consist of small semi-conductor layers.
[0015] Thus, good ohmic contact in an up electrode and a contact layer is attained by that the band gap of a contact layer is small. Moreover, by preparing said lens layer, said contact layer can be thin-film-ized and the light absorption loss by the contact layer can be suppressed to the minimum. Thereby, coexistence with improvement in ohmic contact and prevention of light absorption loss can be aimed at.
[0016] As for said lens layer, it is desirable to take the configuration of a publication below.
[0017] ** Said lens layer is set to the 1st from two or more layers from which a refractive index differs, and the refractive index of this lens layer is changing to it in multistage.
[0018] Thus, if the refractive index is changing in multistage, when a lens layer is the spherical surface-like,

spherical aberration can be amended effectively.
[0019] moreover — the case where said lens layer consists of this configuration — said lens layer — the 1st lens layer — this — it is still more desirable to locate said 2nd lens layer in a high order from said 1st lens layer including the 2nd lens layer with a larger refractive index than the 1st lens layer.
[0020] When the 1st lens layer shortens a focal distance and the 2nd lens layer lengthens a focal distance by taking such a configuration, spherical aberration can be amended certainly.
[0021] ** Said lens layer is a layer from which a refractive index changes to the 2nd continuously.
[0022] Since spherical aberration exists continuously, when a refractive index uses a lens layer as the layer which changed continuously, it can amend spherical aberration still more certainly.
[0023] As for said pillar-shaped section, it is desirable that it is a mesa-like. Thereby, the valley of the current which flows from an up electrode to a lower electrode can be demarcated.
[0024] Moreover, said pillar-shaped section may have the shape of a curved surface where the side face is gently-sloping. The uniform up electrode of thickness can be formed, and thereby, coverage improves and it is hard coming to generate an open circuit according to the side face of the pillar-shaped section being gently-sloping.
[0025] Moreover, the field luminescence mold semiconductor laser concerning this invention can be formed by the manufacture approach containing following process (a) - (d).
[0026] (a) The process which deposits two or more semi-conductor layers, and forms a semi-conductor deposition object on half-******, (b) The process which forms the 1st resist layer of a predetermined pattern on said semi-conductor deposition object, (c) The process which is made to heat and carry out a reflow of said 1st resist layer, fabricates this resist layer in a convex lens-like configuration, and forms the 2nd resist layer, and (d) etching remove said 2nd resist layer at least. The process which forms the lens configuration section by which the configuration of said 2nd resist layer was reflected in the upper part of said semi-conductor deposition object.
[0027] According to this manufacture approach, since the pillar-shaped section and the lens configuration section can be formed by the self aryne, optical-axis doubling is unnecessary and does not produce an optical-axis gap, either.
[0028] The configuration of the lens configuration section in said process (d) can apply the thing of a configuration of having mentioned above.
[0029] As for the etch selectivity (henceforth a "selection ratio") of a semi-conductor deposition object to the resist layer in etching of said process (d), it is desirable that it is 0.5-1.0. The lens configuration section of desired curvature can be formed by making a selection ratio small like 0.5-1.0, reflecting the configuration of said 2nd resist layer in the upper part of said semi-conductor deposition object.
[0030] Moreover, as for etching of said process (d), it is desirable to be made by the reactant ion-beam-etching approach which added oxygen to chlorine-based gas. Thereby, a selection ratio is controllable by adjusting the amount of oxygen. Consequently, a lens configuration is easily controllable.
[0031] Furthermore, as for the manufacture approach of this invention, it is desirable to have the process (e) which etches said some of semi-conductor deposition objects by using said 2nd resist layer as a mask, and forms the semi-conductor deposition object of the shape of a mesa-like column after said process (c).
[0032] Since it requires only changing etching gas for the shift to etching [at the time of using the same mask for formation with the pillar-shaped section and the lens configuration section, and forming the pillar-shaped section] at the time of forming the lens configuration section from etching according to this approach, the above-mentioned process can be advanced easily.
[0033] Moreover, in not including said process (e), it is formed at the process that the pillar-shaped section and the lens configuration section are the same, and the inclination of the side face of said semi-conductor deposition object becomes gently-sloping. The uniform up electrode of the thickness whose coverage improved can be formed by this, and it is hard coming to generate an open circuit of an up electrode.
[0034] Although especially the resist ingredient used for formation of said 1st resist layer at said process (b) is not limited, its heat-resistant low photoresist etc. is desirable in comparison.
[0035]
[Embodiment of the Invention] Hereafter, the gestalt of suitable operation of this invention is explained, referring to a drawing.
[0036] (Gestalt of the 1st operation)
(Structure of a device) Drawing 1 is the sectional view showing typically the field luminescence mold semiconductor laser (henceforth a "surface emission-type laser") concerning the gestalt of operation of the 1st

of this invention.

[0037] The distribution reflective mold multilayers mirror of 25 pairs to which the surface emission-type laser 100 shown in drawing 1 carried out the laminating of aluminum0.15Ga0.85As and the AlAs by turns on the n mold GaAs substrate 109 (Hereafter) it is called a "lower DBR mirror" — GaAs with a 104 and a thickness of 3nm — a well — from a layer and an aluminum0.3Ga0.7As barrier layer with a thickness of 3nm — changing — this — a well — a layer the quantum well barrier layer 105 which consists of three layers, aluminum0.15Ga0.85As, and aluminum0.9Ga0.1As The laminating of the distribution reflective mold multilayers mirror (henceforth an "up DBR mirror") 103 and the contact layer 102 of 30 pairs which carried out the laminating by turns is carried out one by one, and they are formed.

[0038] The up DBR mirror 103 is used as p mold by doping Zn, and let the lower DBR mirror 104 be n mold by doping Se. Therefore, a pin diode is formed by the quantum well barrier layer 105 and the lower DBR mirror 104 by which the up DBR mirror 103 and the impurity are not doped.

[0039] The contact layer 102 needs to be the quality of the material which is mentioned later and in which the up electrode 106 and ohmic contact are possible, and consists of aluminum0.15Ga0.85As by which it was doped in the case of the AlGaAs system ingredient (for example, three or more [1019cm -] high-concentration impurities).

[0040] The pillar-shaped section 101 is formed by etching in the shape of a mesa except for a predetermined field to the middle of the contact layer 102, the up DBR mirror 103, the quantum well barrier layer 105, and the lower DBR mirror 104. The top face of the contact layer 102 serves as a convex lens configuration at the top face of the pillar-shaped section 101, and the concrete target. Hereafter, the convex lens configuration section prepared on the up DBR mirror 103 is only called lens configuration section 115.

[0041] Furthermore, the side face of the pillar-shaped section 101 reaches in part, and as an insulating layer 108 covers the top face of the lower DBR mirror 104, it is formed.

[0042] And on the top face of the pillar-shaped section 101, as the up electrode 106 contacts the contact layer 102 and in the shape of a ring and covers a part of side face of the exposed pillar-shaped section 101, and front face of an insulating layer 108, it is formed. Moreover, the lower electrode 107 is formed in the bottom of the n mold GaAs substrate 109.

[0043] With the up electrode 106 and the lower electrode 107, if the electrical potential difference of the forward direction is impressed to a pin diode, in the quantum well barrier layer 105, the recombination of an electron and an electron hole will happen and recombination radiation will arise. Then, in case the produced light goes back and forth between the up DBR mirror 103 and the lower DBR mirrors 104, induced emission happens and luminous intensity is amplified. If the Mitsutoshi profit turns around optical loss a top, laser oscillation will happen and outgoing radiation of the laser beam will be perpendicularly carried out from opening of the up electrode 106 to a substrate.

[0044] It being characteristic in the gestalt of this operation is formed in a convex lens configuration, the top face, i.e., the laser outgoing radiation side, of the pillar-shaped section 101, as shown in drawing 1 R> 1. Thereby, in a laser outgoing radiation side, a laser beam can be made refracted and the radiation angle can be narrowed. Moreover, according to this, since a radiation angle is controllable in a laser outgoing radiation side, even if it enlarges laser outgoing radiation aperture, it also becomes possible to set up a radiation angle small.

[0045] (Manufacture process of a device) Next, the manufacture process of a surface emission-type laser 100 shown in drawing 1 is explained. Drawing 2 - drawing 6 are the mimetic diagrams having shown the production process of a surface emission-type laser 100.

[0046] (a) Explain first, referring to drawing 2 . On the n mold GaAs substrate 109, the laminating of aluminum0.15Ga0.85As and the AlAs is carried out by turns, and the lower DBR mirror 104 of 25 pairs which doped Se is formed. next, the lower DBR mirror 104 top — GaAs with a thickness of 3nm — a well — from a layer and an aluminum0.3Ga0.7As barrier layer with a thickness of 3nm — changing — this — a well — a layer forms the quantum well barrier layer 105 which consists of three layers. Furthermore, on the quantum well barrier layer 105, the laminating of aluminum0.15Ga0.85As and the aluminum0.9Ga0.1As is carried out by turns, and the up DBR mirror 103 of 30 pairs which doped Zn is formed. Then, the laminating of the contact layer 102 which consists of aluminum0.15Ga0.85As on the up DBR mirror 103 is carried out.

[0047] above-mentioned each class — organic metal vapor growth (MOVPE:Metal-OrganicVapor Phase Epitaxy) — epitaxial growth can be carried out by law. 750 degrees C and a growth pressure are 2x104Pa, at this time, for example, growth temperature, the organic metal of TMGa (trimethylgallium) and TMAl (trimethylaluminum) can be used for an III group raw material, and it can use DEZn (dimethyl zinc) for V group raw material at H2Se and p mold dopant at AsH3 and n mold dopant.

[0048] Next, on the contact layer 102, after applying a photoresist, as shown in drawing 2 , the 1st resist layer R1 of a predetermined pattern is formed by carrying out patterning of the photoresist, with photolithography.
[0049] (b) Subsequently, make heating and a reflow, i.e., the fused resist, flow, and carry out the reconstitution of the 1st resist layer R1. Thereby, the 1st resist layer R1 deforms in response to the effect of surface tension in the shape of [as shown in drawing 3] a convex lens, and the 2nd resist layer R2 is formed. For example, it can carry out, using a hot plate or warm air circuit system oven as the heating approach. Although the conditions at the time of using a hot plate change according to the quality of the material of a resist, they are 150 degrees C or more, and are 5 minutes preferably for 2 to 10 minutes. Moreover, in the case of warm air circuit system oven, it is 160 degrees C or more, and 20 - 30 minutes is suitable for it.
[0050] (c) Subsequently, as shown in drawing 4 , by using the 2nd resist layer R2 as a mask, stopping the lens configuration of the 2nd resist layer R2 to the middle of the contact layer 102, the up DBR mirror 103, the quantum well barrier layer 105, and the lower DBR mirror 104, by the reactive-ion-etching method, etch in the shape of a mesa and form the pillar-shaped section 101. The reactant ion-beam-etching method for having used chlorine or chlorine-based gas (a hydrogen chloride, BCl3) as etching gas is usually used for this etching. As for the selection ratio of this etching, it is desirable that it is 2.0 or more. Under the present circumstances, in the range which does not affect a selection ratio, in order to stabilize the plasma state, Ar may be added.
[0051] (d) After that, by the dry etching method which are 0.5-1.0, a selection ratio etches the 2nd resist layer R2 and lower DBR mirror 104, and makes the top face of the contact layer 102 a convex lens configuration. In this etching, the configuration of the shape of that convex lens is imprinted in the contact layer 102, making the lens configuration of the 2nd resist layer R2 as a fictitious outline shows, before performing an etching process by drawing 5 reflect. As a dry etching method, the reactant ion-beam-etching method which added oxygen in the amount of oxygen in the chlorine-based gas which can adjust a selection ratio is desirable. Moreover, the ion-beam-etching method using Ar gas is also applicable.
[0052] (e) Subsequently, form silicon oxide (SiOX film) of 100-300nm of thickness on a substrate using SiH4 (mono silane) gas and O2 (oxygen) gas with the ordinary pressure heat CVD method which makes N2 (nitrogen) gas carrier gas. Then, by the photolithography and dry etching, as shown in drawing 1 , except for a part of side face of the pillar-shaped section 101, and a part of lower DBR mirror 104, etching removal of the silicon oxide is carried out, and an insulating layer 108 is formed.
[0053] Subsequently, with a vacuum deposition method, on the lower DBR mirror 104, an Au-Zn alloy layer is formed, using the photolithography method, as shown in drawing 1 , etching removal of this alloy layer is carried out, and the up electrode 106 is formed so that the top face of the pillar-shaped section 101 may be exposed.
[0054] Then, the lower electrode 107 which consists of an Au-germanium alloy layer is formed in the inferior surface of tongue of a substrate 109 by the vacuum deposition method, and field luminescence laser as shown in drawing 1 is completed.
[0055] Thus, in order to form the pillar-shaped section 101 and the lens configuration section 115 by the self aryne, optical-axis doubling is unnecessary and does not produce an optical-axis gap, either. Moreover, since it requires only changing etching gas for the shift to etching [at the time of using the same mask for formation with the pillar-shaped section 101 and the lens configuration section 115, and forming the pillar-shaped section 101] at the time of forming the lens configuration section 115 from etching, the above-mentioned process can be advanced smoothly.
[0056] The surface emission-type laser of the AlGaAs system in the gestalt of this operation is preferably applicable in consideration of the presentation of a contact layer in the laser oscillation wavelength of 780nm or more which the absorption between bands in this contact layer of a laser beam does not produce.
[0057] (Gestalt of the 2nd operation)
(Structure of a device) Drawing 7 is the sectional view showing typically the surface-emission-type laser 200 concerning the gestalt of operation of the 2nd of this invention.
[0058] The surface emission-type laser 200 concerning the gestalt of this operation differs from the gestalt of the 1st operation at the point of the layer structure of the semi-conductor layer of the lens configuration section 115 in the pillar-shaped section 101. About the configuration of those other than this, since it is the same as that of the gestalt of the 1st operation, detailed explanation is omitted. The surface emission-type laser 100 which starts the gestalt of the 1st operation in the gestalt of this operation, and ** which gives the same sign to the part which has the same function substantially.
[0059] The layer structure of the lens configuration section 115 has taken the configuration by which the lens layer 110 was further formed on the contact layer 102. Moreover, the top face of the lens configuration section

115 consists of a part of top face of the lens layer 110, and top face of the contact layer 102, and is constituted from a core by concentric circular in detail in order of [a part of] the top face of the lens layer 110, and the top face of the contact layer 102 subsequently to exposed to the surroundings of it in the shape of a ring. The contact layer 102 consists of GaAs by which a semi-conductor with a small band gap, for example, a high-concentration impurity, was doped for the purpose of securing the ohmic contact to the contact layer 102 and the up electrode 106. On the other hand, depending on laser oscillation wavelength, absorption loss of a laser beam may start by absorption between bands in the contact layer 102 with a small band gap. In consideration of this, the contact layer 102 is thin-film-ized to 500-1000nm of thickness which can suppress absorption loss of the laser beam by the contact layer to the minimum, for example, thickness.
[0060] Furthermore, the function as the lens configuration section 115 is not secured only in the contact layer 102 by having thin-film-ized the contact layer 102. Then, the lens layer 110 is formed on the contact layer 102 for the purpose of making a lens function discover certainly. A band gap is a bigger semi-conductor than the energy of a laser beam, and the lens layer 110 consists of aluminum0.5Ga0.5As of the semi-conductor which optical loss by free carrier dispersion cannot produce easily, for example, low carrier concentration, and a non dope etc.
[0061] It being characteristic in the gestalt of this operation is having formed the lens layer 110, in order to thin-film-ize the contact layer 102 and to secure a lens function. When the band gap of the contact layer 102 is smaller than the band gap equivalent to the energy of a laser beam, absorption loss of the laser beam by the contact layer 102 arises. However, with the gestalt of this operation, the contact layer 102 is thin-film-ized like the above-mentioned description to the thickness which can suppress absorption loss of the laser beam by the contact layer 102 to the minimum. For this reason, it becomes possible to apply the semi-conductor which has a band gap smaller than the energy of a laser beam to the contact layer 102. Consequently, since ohmic contact is made easy to take, rather than the energy of a laser beam, the band gap of the contact layer 102 can be made small, and, thereby, the contact resistance of the up electrode 106 and the contact layer 102 can be reduced.
[0062] As mentioned above, according to the gestalt of this operation, in a laser outgoing radiation side, a laser beam can be made refracted and the radiation angle can be narrowed by the lens configuration section 115 which has a convex lens configuration. Moreover, according to this, since a radiation angle is controllable in a laser outgoing radiation side, even if it enlarges laser outgoing radiation aperture, it also becomes possible to set up a radiation angle small. Furthermore, rather than the energy of a laser beam, the band gap of the contact layer 102 can be made small, and, thereby, the contact resistance of the up electrode 106 and the contact layer 102 can be reduced.
[0063] (Manufacture process of a device) As the manufacture approach of the surface emission-type laser 200 in the gestalt which is this operation, the contact layer which consists of GaAs of 500-1000nm of thickness after up DBR mirror formation in the (a) process in the gestalt of the 1st operation is formed, and the lens layer 110 which consists of aluminum0.5Ga0.5As of 2000-3000nm of thickness is further formed on a contact layer. The same approach as the gestalt of the 1st operation can be used except it.
[0064] Thus, in order to form the pillar-shaped section 101 and the lens configuration section 115 by the self aryne, optical-axis doubling is unnecessary and does not produce an optical-axis gap, either. Moreover, since it requires only changing etching gas for the shift to etching [at the time of using the same mask for formation with the pillar-shaped section 101 and the lens configuration section 115, and forming the pillar-shaped section 101] at the time of forming the lens configuration section 115 from etching, the above-mentioned process can be advanced smoothly.
[0065] Although the surface emission-type laser of the AlGaAs system in the gestalt of this operation is applicable regardless of laser oscillation wavelength, in the case of laser oscillation wavelength 800nm or less, it is especially effective, for example.
[0066] (Gestalt of the 3rd operation)
(Structure of a device) Drawing 8 is the sectional view showing typically the surface emission-type laser 300 concerning the gestalt of operation of the 3rd of this invention.
[0067] The surface emission-type laser 300 concerning the gestalt of this operation differs from the gestalt of the 1st operation at the point of the layer structure of the semi-conductor layer of the lens configuration section 115. About the configuration of those other than this, since it is the same as that of the gestalt of the 1st operation, detailed explanation is omitted. The surface emission-type laser which starts the gestalt of the 1st operation in the gestalt of this operation, and ** which gives the same sign to the part which has the same function substantially.

[0068] The lens layer 110 is formed on the contact layer 102 of the lens configuration section 115. As compared with the low refractive-index lens layer 111 and it, the laminating of the high refractive-index lens layer 112 with a large refractive index is carried out one by one, and the lens layer 110 is formed. and a part of top face of the contact layer 102 where it consists of GaAs which exposed the top face of the lens configuration section 115 in the shape of a ring in order to contact an up electrode around it further, a part of top face 112 of a high refractive-index lens layer, top face of the low refractive-index lens layer 111 exposed to the surroundings of it in the shape of a ring, and — concentric circular — and it is constituted so that the same curved surface may be made.

[0069] The high refractive-index lens layer 112 has the role which makes the focal distance of incident light small, for example, consists of aluminum0.2Ga0.8As.

[0070] The low refractive-index lens layer 111 has the role which enlarges the focal distance of incident light, and consists of the quality of the material with a refractive index smaller than the high refractive-index lens layer 112, for example, aluminum0.8Ga0.2As.

[0071] It being characteristic in the gestalt of this operation is that the top face of the lens configuration section 115 comes to contain a part of top face of the high refractive-index lens layer 112, and top face of the low refractive-index lens layer 111 exposed to the surroundings of it in the shape of a ring.

[0072] According to this configuration, even if the top face of the pillar-shaped section 101 is a simple curved surface, i.e., a spherical surface convex lens configuration, it can discover a compound curved surface, i.e., effectiveness equivalent to an aspheric surface convex lens configuration. That is, in the case of a configuration with the convex lens configuration of the top face of the pillar-shaped section 101 near the spherical surface or the spherical surface, the phenomenon in which the focal distance of the light which carried out incidence to Lens L becomes small produces a lens as it goes in the direction of a path from an optical axis so that it may be shown in spherical aberration, i.e., drawing 9 . In order to amend this spherical aberration, the lens of the aspheric surface configuration which made small the curvature of the curved surface of the direction lateral part of a path from the optical axis of a lens is usually used.

[0073] The top face of the plantar-flexion chip box lens layer 112 is formed in a center section, the top face of the lens configuration section 115 of the pillar-shaped section 101 concerning the gestalt of this operation is exposed to the surroundings of it in the shape of a ring, and it has come to form a part of top face of the plantar-flexion chip box lens layer 111 with a small refractive index as compared with it. Thereby, spherical aberration can be amended, without aspheric-surface-izing the top face of the pillar-shaped section 101. That is, the focal distance of the light which carried out incidence of the place where the focal distance of the light which carried out incidence becomes small to this part by having prepared the exposure of the plantar-flexion chip box lens layer 112 with a small refractive index in the surroundings of the high dioptric lens layer 111 as compared with it can be enlarged as it goes in the direction of a path from that core in the case of the lens configuration section 115 which has a configuration near the spherical surface or the spherical surface. Thereby, amendment of spherical aberration can be made easy.

[0074] Moreover, in case the lens configuration section 115 is formed making the configuration of the 2nd resist layer R2 after a reflow reflect, even if it is the case where detailed configuration control cannot be performed, a desired lens property can be acquired by controlling the refractive index of these lens layer 111,112.

[0075] (Manufacture process of a device) As the manufacture approach of the surface emission-type laser 300 in the gestalt of this operation In the (a) process in the gestalt of the 1st operation, the contact layer 102 which consists of GaAs of 500-1000nm of thickness after up DBR mirror 103 formation is formed. Subsequently On the contact layer 102, aluminum0.8Ga0.2As of 500-1500nm of thickness is formed as a low refractive-index lens layer 111. Further as a high refractive-index lens layer 112 Except having formed aluminum0.2Ga0.8As of 500-1500nm of thickness, it is the same as that of the gestalt of the 1st operation.

[0076] It has the following advantages on a process by forming the low refractive-index lens layer 111 on the contact layer 102, and forming the high refractive-index lens layer 112 on it further as mentioned above. In case the lens configuration section 115 is formed making the configuration of the 2nd resist layer R2 after a reflow reflect, even if it is the case where detailed configuration control cannot be performed, a desired lens property can be acquired by controlling the refractive index of these lens layer 111,112.

[0077] Thus, in order to form the pillar-shaped section 101 and the lens configuration section 115 by the self aryne, optical-axis doubling is unnecessary and does not produce an optical-axis gap, either. Moreover, since it requires only changing etching gas for the shift to etching [at the time of using the same mask for formation with the pillar-shaped section 101 and the lens configuration section 115, and forming the pillar-shaped section 101]

at the time of forming the lens configuration section 115 from etching, the above-mentioned process can be advanced smoothly.

[0078] The lens layer of this invention is not limited to the two-layer structure. For example, the refractive index of the lens layer which the presentation was continuously changed at the time of crystal growth, and was obtained may be the monolayer which changed continuously sequentially from the lower layer.

[0079] (Gestalt of the 4th operation)

(Structure of a device) Drawing 10 is the sectional view showing typically the surface emission-type laser 400 concerning the gestalt of operation of the 4th of this invention.

[0080] The surface emission-type laser 400 shown in drawing 10 on the n mold GaAs substrate 109 GaAs with the lower DBR mirror 104, a quantum well barrier layer [105], and a thickness of 3nm — a well — from a layer and an aluminum0.3Ga0.7As barrier layer with a thickness of 3nm — changing — this — a well — a layer the quantum well barrier layer 105 which consists of three layers, aluminum0.15Ga0.85As, and aluminum0.9Ga0.1As Distribution reflective mold multilayers mirror (henceforth "1st up DBR mirror") 103a of five pairs which carried out the laminating by turns, The laminating of distribution reflective mold multilayers mirror (henceforth "2nd up DBR mirror") 103b and the contact layer 102 of the current constriction layer 120 and 20 pairs which carried out the laminating of aluminum0.15Ga0.85As and the aluminum0.9Ga0.1As by turns is carried out one by one, and they are formed. The contact layer 102 can apply the same quality of the material as the gestalt of the 1st operation.

[0081] 1st up DBR mirror 103a and 2nd up DBR mirror 103b are used as p mold by doping Zn, and let the lower DBR mirror 104 be n mold by doping Se. Therefore, a pin diode is formed by the 1st quantum well barrier layer 105 and lower DBR mirror 104 by which up DBR mirror 103a and an impurity are not doped.

[0082] With the gestalt of this operation, since the quantum well barrier layer 105 is formed below the pillar-shaped section 101, it needs to demarcate the valley of a current so that the current poured in from the up electrode 106 may be intensively flowed to the core of the quantum well barrier layer 105. The current constriction layer 120 is formed as a means to demarcate the valley of this current. The current constriction layer 120 consists of insulator layer 120b formed as enclosed semi-conductor layer 120a and it which were prepared in the core. This semi-conductor layer 120a consists of AlAs. Moreover, insulator layer 120b consists of an oxide which above-mentioned semi-conductor layer 120a is oxidized, and is obtained. Moreover, as for the current constriction layer 120, in the oxidation process explained later, it is desirable to be formed below the middle of the lower limit of 1st up DBR mirror 103a and the upper limit of 2nd up DBR mirror 103b in the range which does not affect the crystal of a surrounding semi-conductor.

[0083] The pillar-shaped section 101 is formed by etching except for a predetermined field to the middle of the contact layer 102, 2nd up DBR mirror 103b, the current constriction layer 120, and 1st up DBR mirror 103a. The pillar-shaped section 101 has the side face which inclined gently-sloping. Moreover, the contact layer 102 forms the lens configuration section 115 in the upper part of the pillar-shaped section 101, and a concrete target, and the top face serves as a convex lens configuration at them.

[0084] And on the top face of the pillar-shaped section 101, the up electrode 106 contacts the contact layer 102 and in the shape of a ring, and as it covers the side face of the pillar-shaped section 101, and 1st up DBR mirror 103a, it is formed. Moreover, the lower electrode 107 is formed in the bottom of the n mold GaAs substrate 109.

[0085] Next, actuation of a surface emission-type laser 400 is explained.

[0086] when the electrical potential difference of the forward direction is impressed to a pin diode with the up electrode 106 and the lower electrode 107, the arrow head of drawing 10 shows — as — the order from 2nd up DBR mirror 103b — semi-conductor layer 120a of the current constriction layer 120, and 1st up DBR mirror 103a — a passage — the quantum well barrier layer 105 — a current — flowing . Thereby, in the quantum well barrier layer 105, the recombination of an electron and an electron hole happens and recombination radiation arises. Then, in case the produced light goes back and forth between the up DBR mirrors 103a and 103b and the lower DBR mirrors 104, induced emission happens and luminous intensity is amplified. If the Mitsutoshi profit turns around optical loss a top, laser oscillation will happen and outgoing radiation of the laser beam will be perpendicularly carried out from opening of the up electrode 106 to a substrate.

[0087] It being characteristic in the gestalt of this operation is having taken the configuration with the gently-sloping inclination of the side face of the pillar-shaped section 101, as shown in drawing 1010 . thereby, in case the up electrode 106 is formed, it has uniform thickness — it can form up electrode 106. Consequently, an open circuit of the up electrode 106 can be made hard to produce.

[0088] As mentioned above, since the top face of the contact layer 102 which is a laser outgoing radiation side has the convex lens configuration according to the gestalt of this operation, in a laser outgoing radiation side, a

laser beam can be made refracted and the radiation angle can be narrowed. Moreover, according to this, since a radiation angle is controllable in a laser outgoing radiation side, even if it enlarges laser outgoing radiation aperture, it also becomes possible to set up a radiation angle small.

[0089] Furthermore, an open circuit of the up electrode 106 can be made hard to attain good step coverage and to produce, since the side face of the pillar-shaped section 101 is the gently-sloping configuration of inclination.

[0090] (Manufacture process of a device) Next, the manufacture process of a surface emission-type laser 400 shown in drawing 10 is explained. Drawing 11 – drawing 14 show the production process of a surface emission-type laser 400.

[0091] (a) Explain first, referring to drawing 11 . On the n mold GaAs substrate 109, the laminating of aluminum0.15Ga0.85As and the AlAs is carried out by turns, and the lower DBR mirror 104 of 25 pairs which doped Se is formed. next, the lower DBR mirror 104 top — GaAs with a thickness of 3nm — a well — from a layer and an aluminum0.3Ga0.7As barrier layer with a thickness of 3nm — changing — this — a well — a layer forms the quantum well barrier layer 105 which consists of three layers. Furthermore, on the quantum well barrier layer 105, the laminating of aluminum0.15Ga0.85As and the aluminum0.9Ga0.1As is carried out by turns, and 1st up DBR mirror 103a of five pairs which doped Zn is formed. Subsequently, semi-conductor layer 120c which consists of AlAs is formed in the location which is going to form the current constriction layer 120 on 1st up DBR mirror 103a. On this semi-conductor layer 120c, the laminating of aluminum0.15Ga0.85As and the aluminum0.9Ga0.1As is carried out further by turns, and 2nd up DBR mirror 103b of 20 pairs which doped Zn is formed. Then, the laminating of the contact layer 102 which consists of aluminum0.15Ga0.85As is carried out.

[0092] Epitaxial growth of above-mentioned each class can be carried out by the MOVPE method. 750 degrees C and a growth pressure were 2x104Pa, at this time, for example, growth temperature, the organic metal of TMGa (trimethylgallium) and TMAl (trimethylaluminum) was used for the III group raw material, and it used DEZn (dimethyl zinc) for V group raw material at H2Se and p mold dopant at AsH3 and n mold dopant.

[0093] Next, on the contact layer 102, after applying a photoresist, as shown in drawing 11 , the 1st resist layer R1 of a predetermined pattern is formed by carrying out patterning of the photoresist.

[0094] (b) Subsequently, make heating and a reflow, i.e., the fused resist, the 1st resist layer R1 flow, and perform the reconstititution. Thereby, the 1st resist layer R1 deforms into the 2nd resist layer R2 of a convex configuration as shown in drawing 12 in response to the effect of surface tension. For example, it can carry out, using a hot plate or warm air circuit system oven as the heating approach. Although the conditions at the time of using a hot plate change according to the quality of the material of a resist, they are 150 degrees C or more, and are 5 minutes preferably for 2 to 10 minutes. Moreover, in the case of warm air circuit system oven, it is 160 degrees C or more, and 20 – 30 minutes is suitable for it.

[0095] (c) As shown in drawing 13 after that, by using the 2nd resist layer R2 as a mask, by the dry etching method which are 0.5-1.0, a selection ratio etches to the middle of the contact layer 102, 2nd up DBR mirror 103b, semi-conductor layer 120c, and 1st up DBR mirror 103a, and forms the pillar-shaped section 101. In this etching, that convex configuration is imprinted to the deposit of a semi-conductor, making the convex configuration of the 2nd resist layer R2 before performing an etching process reflect, as the fictitious outline of drawing 12 shows. As a dry etching method, the reactant ion-beam-etching method which added oxygen in the amount of oxygen in the chlorine-based gas which can adjust a selection ratio is desirable. Moreover, the ion-beam-etching method using Ar gas is also applicable.

[0096] (d) Subsequently, as shown in drawing 14 , by exposing semi-conductor layer 120c which consists of AlAs to the bottom of an about 400-degree C steam ambient atmosphere for 1 to 30 minutes, AlAs oxidizes from the exposure to the inside, and the aluminum oxide which is an insulator is formed. Thereby, insulating-layer 120b which consists of an aluminum oxide is formed, and the current constriction layer 120 is formed in the surroundings of semi-conductor layer 120a which consists of AlAs for a core.

[0097] (e) Subsequently, with a vacuum deposition method, on the pillar-shaped section 101 and 1st up DBR mirror 103a, form an Au-Zn alloy layer, using a photolithography and dry etching, as shown in drawing 10 , remove this alloy layer and form the up electrode 106 so that the top face of the contact layer 102 may be exposed.

[0098] Then, the lower electrode 107 which consists of an Au-germanium alloy layer is formed in the inferior surface of tongue of a substrate 109 by the vacuum deposition method, and the field luminescence laser 400 as shown in drawing 10 is completed.

[0099] Making the convex configuration of the 2nd resist layer R2 before etching reflect like the above-mentioned process (d), the convex configuration can be imprinted to the deposit of a semi-conductor, and the lens configuration section 115 and the pillar-shaped section 101 can be formed in coincidence. And the side face of

the pillar-shaped section 101 serves as a gently-sloping configuration. Therefore, the up electrode of uniform thickness can be formed in the side face of the pillar-shaped section 101. Consequently, an open circuit of the up electrode 106 can be made hard to attain good coverage and to produce.

[0100] Moreover, in order to form the pillar-shaped section 101 and the lens configuration section 115 by the self aryne, optical-axis doubling is unnecessary and does not produce an optical-axis gap, either.

[0101] (Gestalt of the 5th operation)

(Structure of a device) Drawing 15 is the sectional view showing typically the surface emission-type laser 500 concerning the gestalt of operation of the 5th of this invention.

[0102] The surface emission-type laser 500 concerning the gestalt of this operation differs from the gestalt of the 4th operation at the point of the configuration of the pillar-shaped section 101. About the configuration of those other than this, since it is the same as that of the gestalt of the 4th operation, the same sign is given to the surface emission-type laser 400 concerning the gestalt of the 4th operation, and the part which has the same function substantially, and detailed explanation is omitted.

[0103] That is, the pillar-shaped section 101 is etched in the shape of a mesa, and is formed, and compared with the gestalt of the 4th operation, the side face of the pillar-shaped section 101 is formed so that inclination may become steep. Furthermore, the lens configuration section 115 is constituted, the upper part 102, i.e., the contact layer, of the pillar-shaped section 101, and the top face has become a convex lens configuration.

[0104] Actuation of the laser oscillation of a surface emission-type laser 500 is the same as that of the gestalt of the 4th operation.

[0105] Since the top face of the contact layer 102 which is a laser outgoing radiation side has the convex configuration as mentioned above according to the gestalt of this operation, in a laser outgoing radiation side, a laser beam can be made refracted and the radiation angle can be narrowed. Moreover, according to this, since a radiation angle is controllable in a laser outgoing radiation side, even if it enlarges laser outgoing radiation aperture, it also becomes possible to set up a radiation angle small.

[0106] (Manufacture process of a device) Next, the manufacture process of a surface emission-type laser 500 shown in drawing 15 is explained. Drawing 16 – drawing 18 show the production process of a surface emission-type laser 500.

[0107] The manufacture approach of the surface emission-type laser 500 concerning the gestalt of this operation can be performed like the gestalt of the 4th operation until it uses the resist layer R1 from the process (a) in the gestalt of the 4th operation to a process (b) (i.e., the 1st) as the 2nd resist layer R2 of a lens configuration. Below, the process after it is explained in full detail.

[0108] (c) As shown in drawing 16, by using the 2nd resist layer R2 as a mask, stopping the lens configuration of the 2nd resist layer R2 to the middle of the contact layer 102 and 2nd up DBR mirror 103b, by the reactive-ion-etching method, etch in the shape of a mesa and form the pillar-shaped section 101. The reactant ion-beam-etching method for having used chlorine or chlorine-based gas (a hydrogen chloride, BCl3) as etching gas is usually used for this etching. As for the selection ratio of this etching, it is desirable that it is 2.0 or more. Under the present circumstances, in the range which does not affect a selection ratio, in order to stabilize the plasma state, Ar may be added.

[0109] (d) As the 2nd resist layer R2 and up DBR mirror 103a are etched and it is shown in drawing 16 by the dry etching method selection ratios are 0.5-1.0, after that, make the top face of the contact layer 102 into a convex lens configuration. In this etching, that lens configuration is imprinted in the contact layer 102, making the lens configuration of the 2nd resist layer R2 before performing an etching process reflect, as the fictitious outline of drawing 5 shows. Under the present circumstances, it is etched into coincidence to the middle of 2nd up DBR mirror 103b, semi-conductor layer 120c, and 1st up DBR mirror 103a. As a dry etching method, the reactant ion-beam-etching method which added oxygen in the amount of oxygen in the chlorine-based gas which can adjust a selection ratio is desirable. Moreover, the ion-beam-etching method using Ar gas is also applicable.

[0110] (e) Subsequently, by exposing semi-conductor layer 120c which consists of AlAs to the bottom of an about 400-degree C steam ambient atmosphere for 1 to 30 minutes, AlAs oxidizes from the exposure to the inside, and the aluminum oxide which is an insulator is formed. Thereby, insulating-layer 120b which consists of an aluminum oxide is formed, and the current constriction layer 120 is formed in the surroundings of semi-conductor layer 120a which consists of AlAs for a core.

[0111] Subsequently, with a vacuum deposition method, on the pillar-shaped section 101 and 1st up DBR mirror 103a, an Au-Zn alloy layer is formed, using a photolithography and dry etching, as shown in drawing 15, this alloy layer is removed and the up electrode 106 is formed so that the top face of the contact layer 102 may be

exposed.

[0112] Then, the lower electrode 107 which consists of an Au-germanium alloy layer is formed in the inferior surface of tongue of a substrate 109 by the vacuum deposition method, and the field luminescence laser 500 as shown in drawing 15 is completed.

[0113] Below, the advantage of the manufacture approach in the gestalt of this operation is explained in full detail.

[0114] Since it depends for the outer diameter of the contact layer 102 after etching, and the current constriction layer 120 on the outer diameter of a resist by etching a deposit in the shape of a mesa by using the 2nd resist layer R2 as a mask like the above-mentioned process (c), and including the process which forms the pillar-shaped section, the contact layer 102 and the current constriction layer 120 which have a desired outer diameter can be formed with a sufficient precision.

[0115] Moreover, in order to form the pillar-shaped section 101 and the lens configuration section 115 by the self aryne, optical-axis doubling is unnecessary and does not produce an optical-axis gap, either.

[0116] Moreover, since the contact layer 102 can be formed with a sufficient precision, the touch area of the contact layer 102 and the up electrode 106 can be made into predetermined magnitude.

[0117] Furthermore, since the current constriction layer 120 can be formed with a sufficient precision, in case it oxidizes in a part of AlAs and the current constriction layer 120 is formed, semi-conductor layer 120a of the current constriction layer 120 can also be formed with a sufficient precision by making the amount of oxidation regularity.

[0118] In the gestalt of the above-mentioned operation, although the field luminescence mold semiconductor laser which consists of an AlGaAs system semi-conductor was described, it is applicable also about the field luminescence mold semiconductor laser which consists of semi-conductors, such as other ingredient systems, for example, a GaInP system, a ZnSSe system, and an InGaN system.

[0119] Moreover, the configuration of the top face of the pillar-shaped section 101 and the lens configuration section 115 is not limited by the gestalt of the above-mentioned operation.

[0120]

[Translation done.]

DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]

[Drawing 1] It is the sectional view showing typically the field luminescence mold semiconductor laser concerning the gestalt of the 1st operation.

[Drawing 2] It is the sectional view showing typically the process of the manufacture approach of the field luminescence mold semiconductor laser concerning the gestalt of the 1st operation.

[Drawing 3] It is the sectional view showing typically the process of the manufacture approach of the field luminescence mold semiconductor laser concerning the gestalt of the 1st operation.

[Drawing 4] It is the sectional view showing typically the process of the manufacture approach of the field luminescence mold semiconductor laser concerning the gestalt of the 1st operation.

[Drawing 5] It is the sectional view showing typically the process of the manufacture approach of the field luminescence mold semiconductor laser concerning the gestalt of the 1st operation.

[Drawing 6] It is the sectional view showing typically the process of the manufacture approach of the field luminescence mold semiconductor laser concerning the gestalt of the 1st operation.

[Drawing 7] It is the sectional view showing typically the field luminescence mold semiconductor laser concerning

the gestalt of the 2nd operation.
[Drawing 8] It is the sectional view showing typically the field luminescence mold semiconductor laser concerning the gestalt of the 3rd operation.
[Drawing 9] It is drawing having shown an example of spherical aberration.
[Drawing 10] It is the sectional view showing typically the field luminescence mold semiconductor laser concerning the gestalt of the 4th operation.
[Drawing 11] It is the sectional view showing typically the process of the manufacture approach of the field luminescence mold semiconductor laser concerning the gestalt of the 4th operation.
[Drawing 12] It is the sectional view showing typically the process of the manufacture approach of the field luminescence mold semiconductor laser concerning the gestalt of the 4th operation.
[Drawing 13] It is the sectional view showing typically the process of the manufacture approach of the field luminescence mold semiconductor laser concerning the gestalt of the 4th operation.
[Drawing 14] It is the sectional view showing typically the process of the manufacture approach of the field luminescence mold semiconductor laser concerning the gestalt of the 4th operation.
[Drawing 15] It is the sectional view showing typically the field luminescence mold semiconductor laser concerning the gestalt of the 5th operation.
[Drawing 16] It is the sectional view showing typically the process of the manufacture approach of the field luminescence mold semiconductor laser concerning the gestalt of the 5th operation.
[Drawing 17] It is the sectional view showing typically the process of the manufacture approach of the field luminescence mold semiconductor laser concerning the gestalt of the 5th operation.
[Drawing 18] It is the sectional view showing typically the process of the manufacture approach of the field luminescence mold semiconductor laser concerning the gestalt of the 5th operation.

[Description of Notations]

100 Surface Emission-type Laser
101 Pillar-shaped Section
102 Contact Layer
103 Up DBR Mirror
103a The 1st up DBR mirror
103b The 2nd up DBR mirror
104 Lower DBR Mirror
105 Quantum Well Barrier Layer
106 Up Electrode
107 Lower Electrode
108 Insulating Layer
109 Substrate
110 Lens Layer
111 Low Refractive-Index Lens Layer
112 High Refractive-Index Lens Layer
115 Lens Configuration Section
120 Current Constriction Layer
120a Semi-conductor layer
120b Insulator layer
120c Semi-conductor layer
R1 1st resist layer
R2 2nd resist layer
L Lens

[Translation done.]

ザを模式的に示す断面図である。

【図２】第１の実施の形態にかかる面発光型半導体レーザの製造方法の工程を模式的に示す断面図である。

【図３】第１の実施の形態にかかる面発光型半導体レーザの製造方法の工程を模式的に示す断面図である。

【図４】第１の実施の形態にかかる面発光型半導体レーザの製造方法の工程を模式的に示す断面図である。

【図５】第１の実施の形態にかかる面発光型半導体レーザの製造方法の工程を模式的に示す断面図である。

【図６】第１の実施の形態にかかる面発光型半導体レーザの製造方法の工程を模式的に示す断面図である。

【図７】第２の実施の形態にかかる面発光型半導体レーザを模式的に示す断面図である。

【図８】第３の実施の形態にかかる面発光型半導体レーザを模式的に示す断面図である。

【図９】球面収差の一例を示した図である。

【図１０】第４の実施の形態にかかる面発光型半導体レーザを模式的に示す断面図である。

【図１１】第４の実施の形態にかかる面発光型半導体レーザの製造方法の工程を模式的に示す断面図である。

【図１２】第４の実施の形態にかかる面発光型半導体レーザの製造方法の工程を模式的に示す断面図である。

【図１３】第４の実施の形態にかかる面発光型半導体レーザの製造方法の工程を模式的に示す断面図である。

【図１４】第４の実施の形態にかかる面発光型半導体レーザの製造方法の工程を模式的に示す断面図である。

【図１５】第５の実施の形態にかかる面発光型半導体レーザを模式的に示す断面図である。

【図１６】第５の実施の形態にかかる面発光型半導体レ

ーザの製造方法の工程を模式的に示す断面図である。

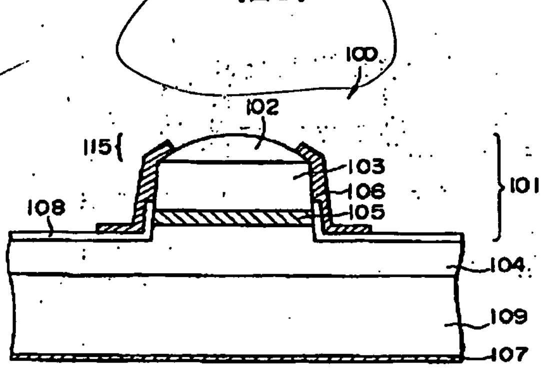
【図１７】第５の実施の形態にかかる面発光型半導体レーザの製造方法の工程を模式的に示す断面図である。

【図１８】第５の実施の形態にかかる面発光型半導体レーザの製造方法の工程を模式的に示す断面図である。

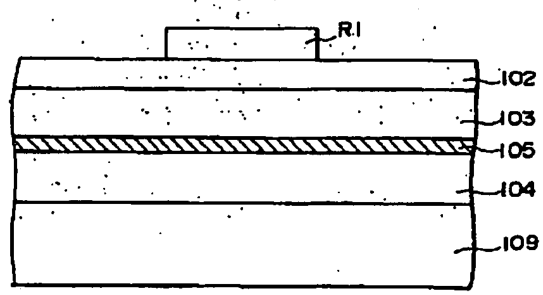
【符号の説明】

１００	面発光レーザ
１０１	柱状部
１０２	コンタクト層
１０３	上部ＤＢＲミラー
１０３ａ	第１の上部ＤＢＲミラー
１０３ｂ	第２の上部ＤＢＲミラー
１０４	下部ＤＢＲミラー
１０５	量子井戸活性層
１０６	上部電極
１０７	下部電極
１０８	絶縁層
１０９	基板
１１０	レンズ層
１１１	低屈折率レンズ層
１１２	高屈折率レンズ層
１１５	レンズ形状部
１２０	電流狭窄層
１２０ａ	半導体層
１２０ｂ	絶縁体層
１２０ｃ	半導体層
Ｒ１	第１のレジスト層
Ｒ２	第２のレジスト層
Ｌ	レンズ

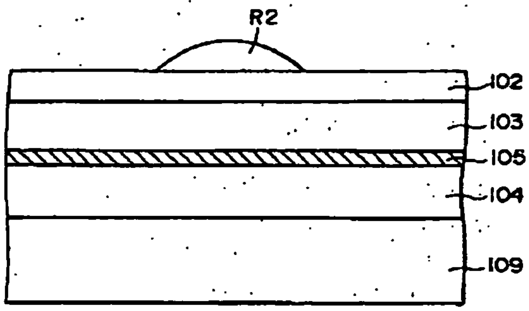
【図１】



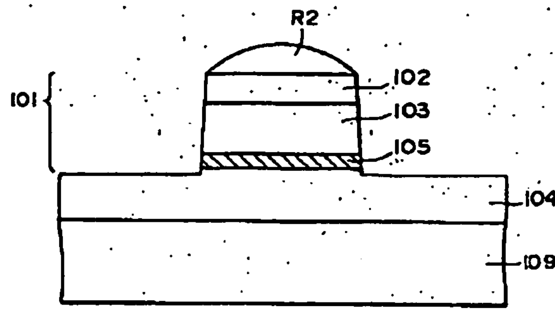
【図２】



【図3】



【図4】



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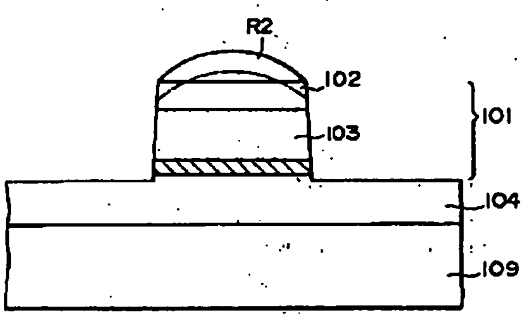

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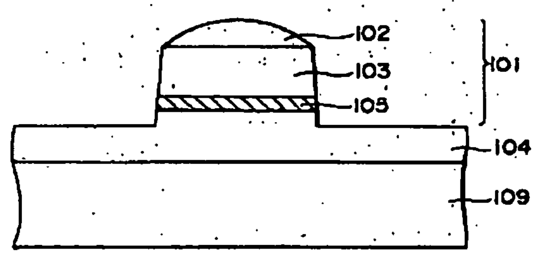

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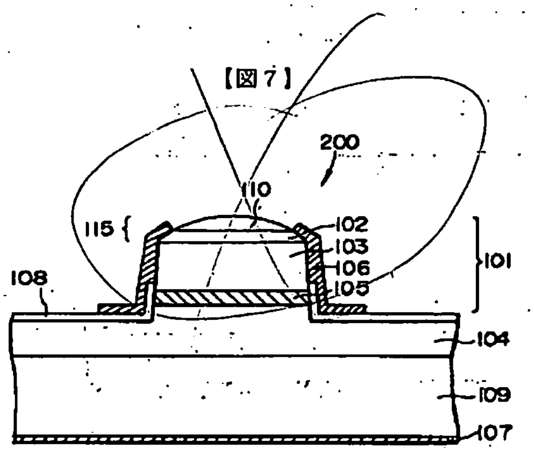
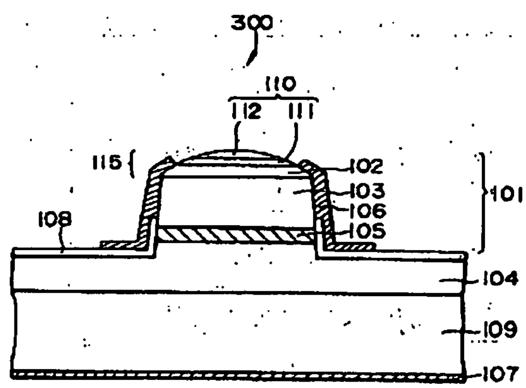
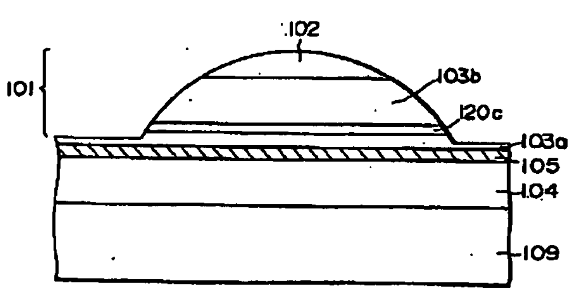


【図8】



【図13】



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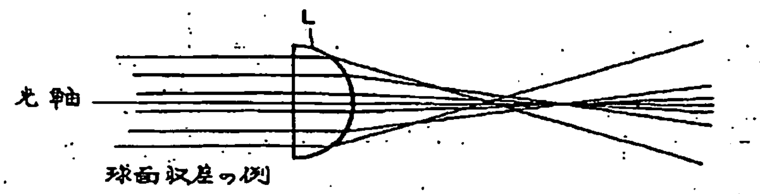
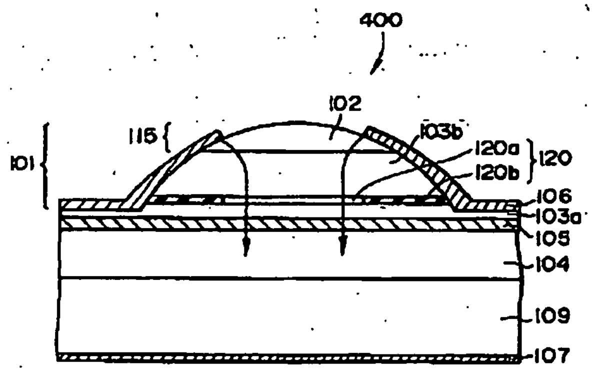
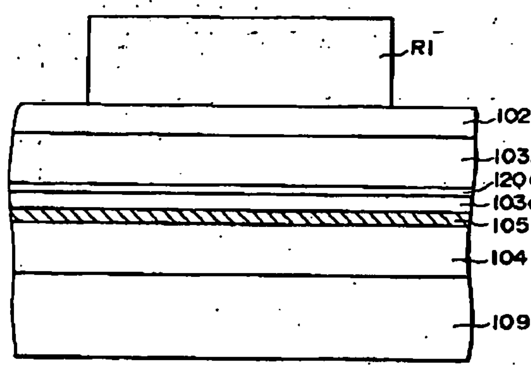


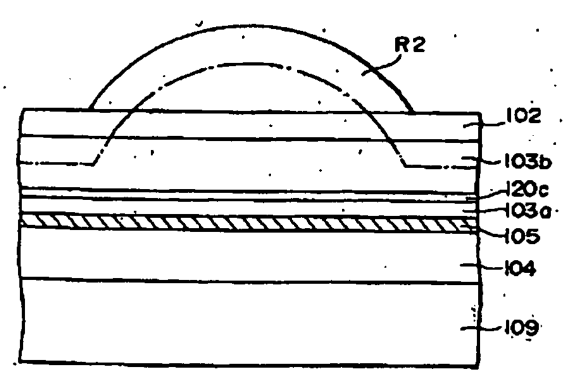
【図10】



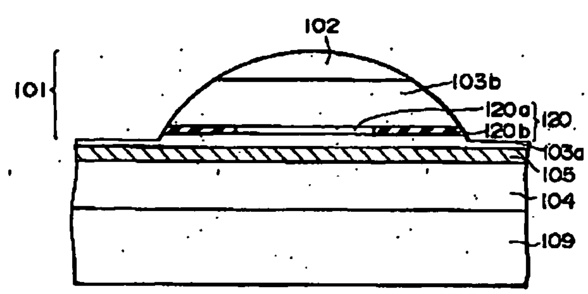
【図11】



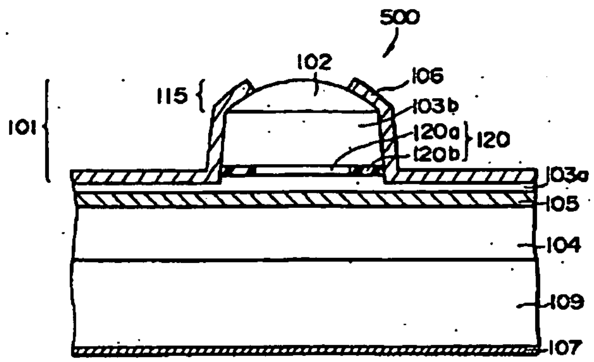
【図12】



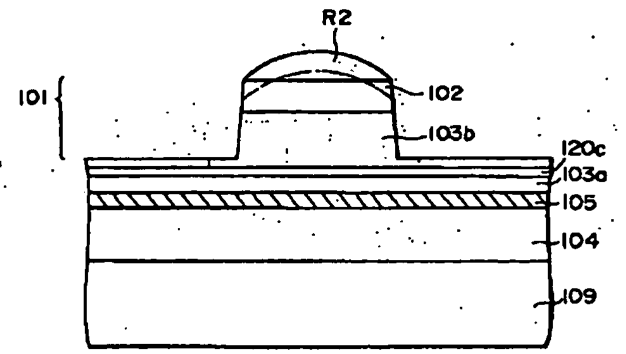
【図14】



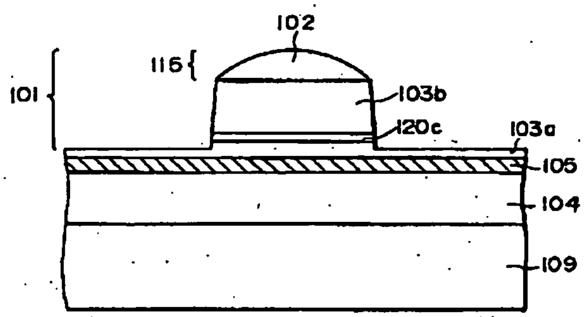
【図15】



【図16】



【図17】



【図18】